ASSA GUI User Manual

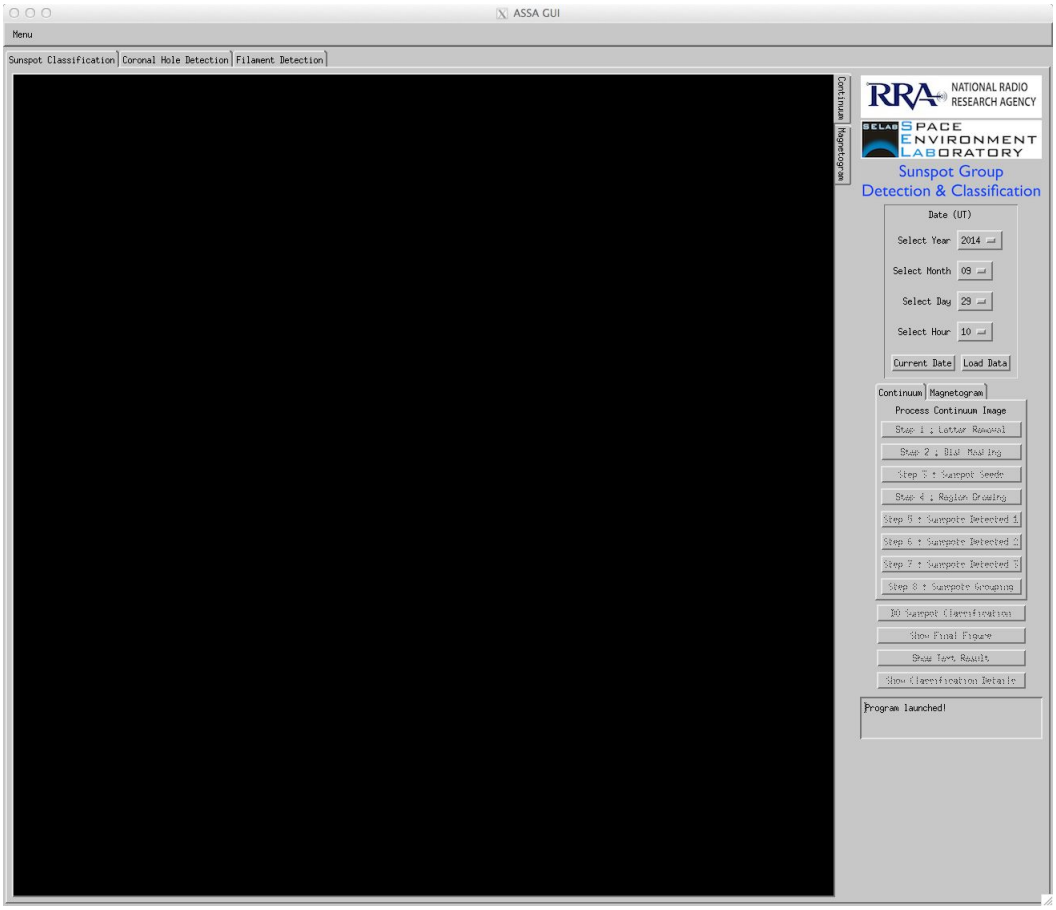
Version 1.12

Last Updated : 2015. 9. 14

1. Introduction

ASSA is an abbreviation of Automatic Solar Synoptic Analyzer, which is a name of the software system developed by the Korean Space Weather Center of the Radio Research Agency and SELab, Inc in Korea. ASSA consists of the following three categories.

1) sunspot group identification and classification
2) coronal hole detection
3) filament detection



For each category, ASSA receives necessary solar raw images and processes them in a designated procedure to yield resultant output files. The whole procedure is performed every hour, and the results are available on following website.

http://www.spaceweather.go.kr/models/assa

ASSA GUI is a standalone program which enables users to emulate the whole procedures of ASSA in their personal computers. It is developed with IDL and wrapped up as a distributable file package, so that every users can use it even if they don't have IDL installed on their

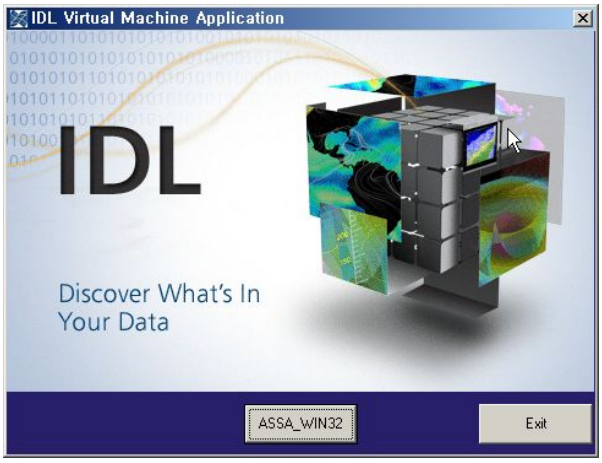
computer. With this program, users can fully experience the detailed procedures of ASSA. It features algorithms for data receiving, image processing, generating output results, etc.. The current version 1.0 will be continuously updated based on feedbacks from users via this website.

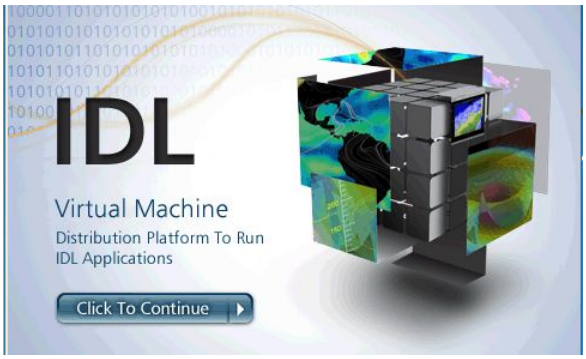
2. Installation

ASSA GUI is currently available on Windows and Mac OS X. Users can download the program package on the following link according to each OS.

Windows : http://www.spweather.com/~lee/ASSA/ASSA_WIN32.zip
Mac OS X : http://www.spweather.com/~lee/ASSA/ASSA_MAC64.zip

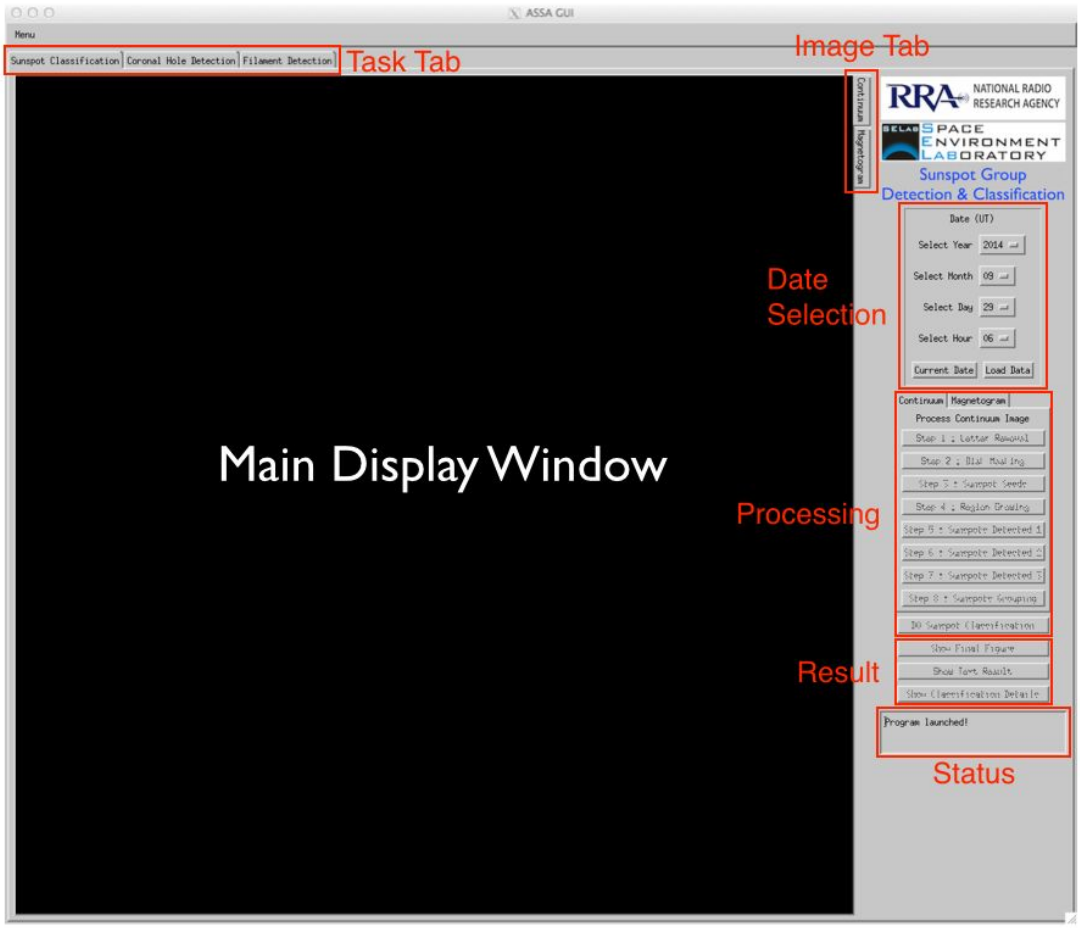
Download the zip file and extract it anywhere you want on your hard drive. Inside the extracted folder, just double click a file named 'ASSA_MAC64.app' on Mac OS X or 'ASSA_WIN32.exe' on Windows. If you already have IDL 8.x version on your PC, the main GUI will appear. If you don't have any IDL installed on your PC, ASSA GUI program will be runned under IDL virtual machine environment, thus two splash pop-ups will appear as followings.





Just press buttons to continue and the main GUI will appear. If you can see the main GUI which

looks like the following figure, you’re ready and set.



3. Sunspot Group Detection and Classification

3.1 GUI Interface

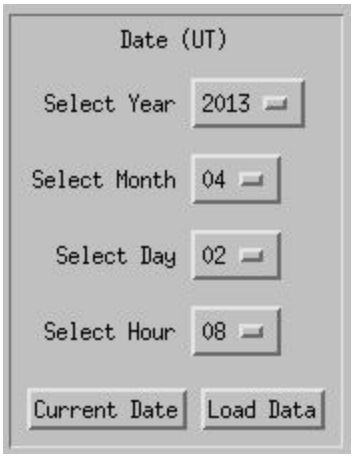
- Description on GUI of sunspot classification

In the ‘Sunspot Classification’ tab, you can identify sunspot group and obtain McIntosh and Mt. Wilson magnetic classification results by processing SDO HMI continuum and magnetogram images. The classification algorithms required for this analysis are developed according to the descriptions on sunspot classification presented by SIDC(Solar Influences Data Analysis Center), which is available on the following link.

http://sidc.oma.be/educational/classification.php

3.2 Getting Raw Data

Date should be specified at the interface for date selection. Year, month, day, hour can be selected for the desired UT date. Any past date may also be selected as far as it can be selected from the pull-down menus. Select the date and time in GUI as the following figure. If you click “Current Date” button, date and time will be automatically set to latest available date and time.



Then click “Load Data” button. ASSA program automatically checks the sub-directory called “data” to find out whether the appropriate files already exist. For sunspot classification, ASSA mainly uses SDO HMI solar continuum image(flattened) and magnetogram image named as

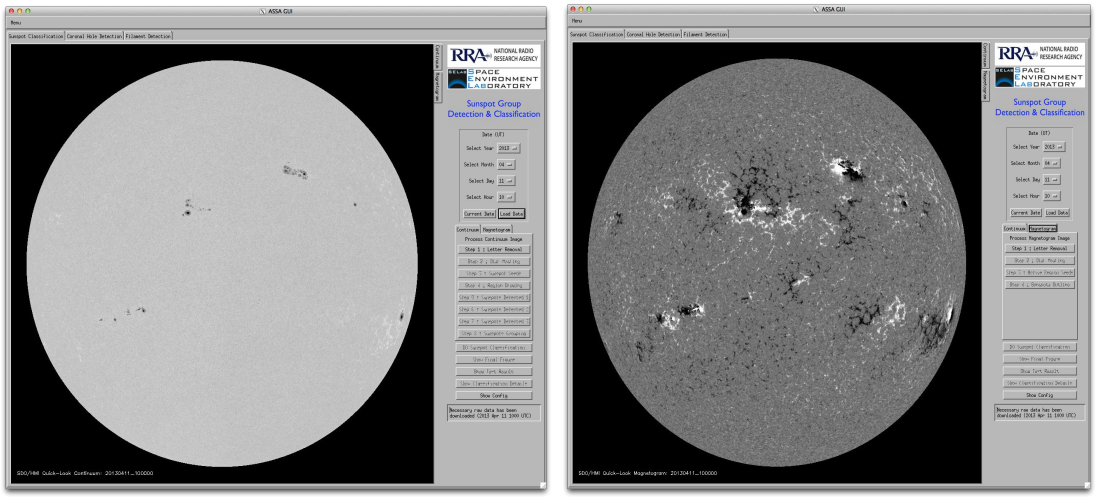
- [YYYY][MM][DD]_[hh][mm][ss]_Ic_flat_1k.jpg : continuum image
- [YYYY][MM][DD]_[hh][mm][ss]_M_1k.jpg : magnetogram image

Additionally, SRS(Solar Region Summary) data issued daily by NOAA is also required. But in case the SRS data for the selected date is not available yet, the whole process continues without it. If there are no appropriate files in “data” directory, ASSA will show a pop-up window

as follows.

Then press “OK”, and ASSA will connect to SDO FTP archive and download the files, which are saved in ASSA data diectory(“data”). If you already have such files in your local disk and these files are named appropriately, just copy them to ASSA data directory. It also works.

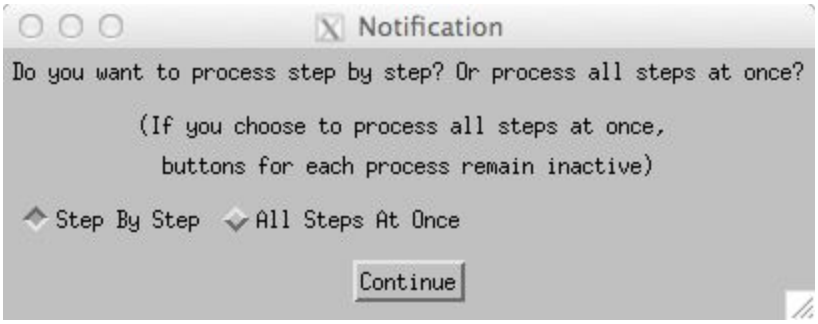
When downloading SDO files is completed, ASSA will show the corresponding continuum and magnetogram images on the main display window as shown in the following figure. You can switch to continuum image or magnetogram image by clicking “Continuum” and “Magnetogram” tabs of Image Tab located at upper-right side of Main Display Window.



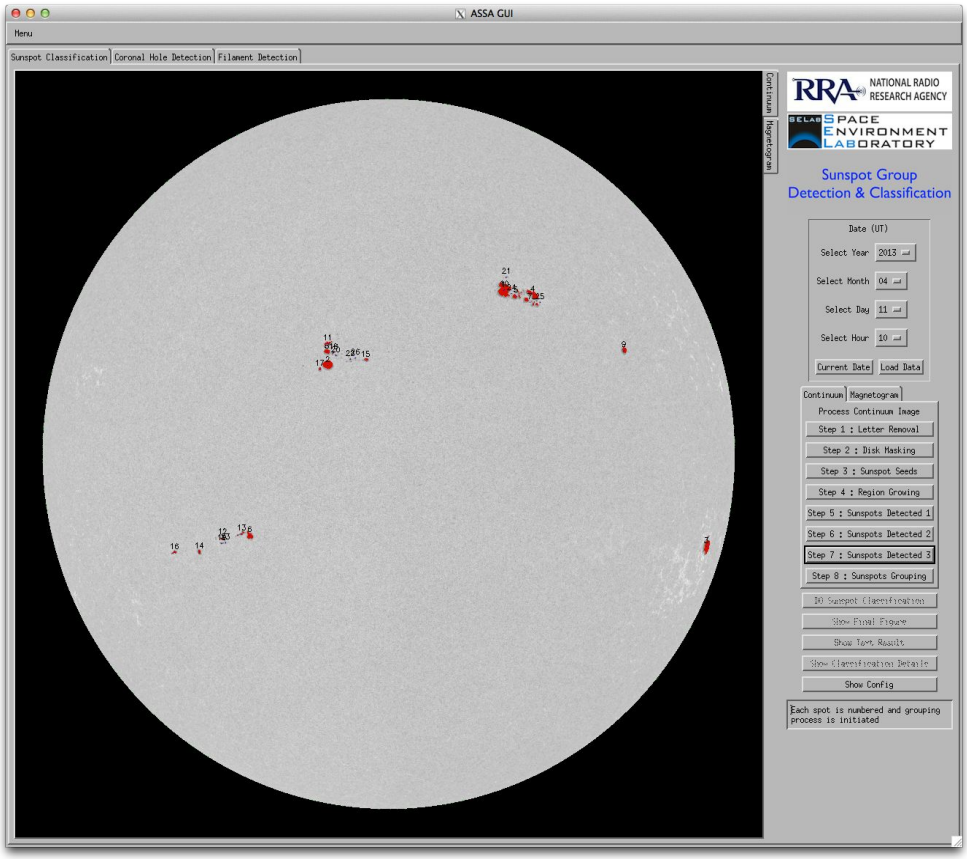
3.3 Data Processing

- Processing continuum and magnetogram images

After the appropriate data files are successfully downloaded and displayed, you may choose either to process all steps one by one by pressing each button or to process all steps at once automatically in order, in a pop-up window which looks as follows. Choose an option and press “Continue” button.


Notification
Do you want to process step by step? Or process all steps at once?
(If you choose to process all steps at once,
buttons for each process remain inactive)
Step By Step
All Steps At Once
Continue

If you choose to process all steps at once automatically in order, you have only to wait for all processes to be completed. If you choose to process all steps one by one, “Step 1” button for “Continuum” and “Magnetogram” tab becomes active. By pressing “Step 1” button, the first procedure for data processing is performed. After it’s done, the button for the next procedure “Step 2” becomes active, and so on. The remaining buttons become active one by one in order according to the designated order of process, which intuitively indicate what to do next for users. Therefore, users can recognize what is done for each process every step of the way. For every step, the display window shows the image resulting from that stage of process.

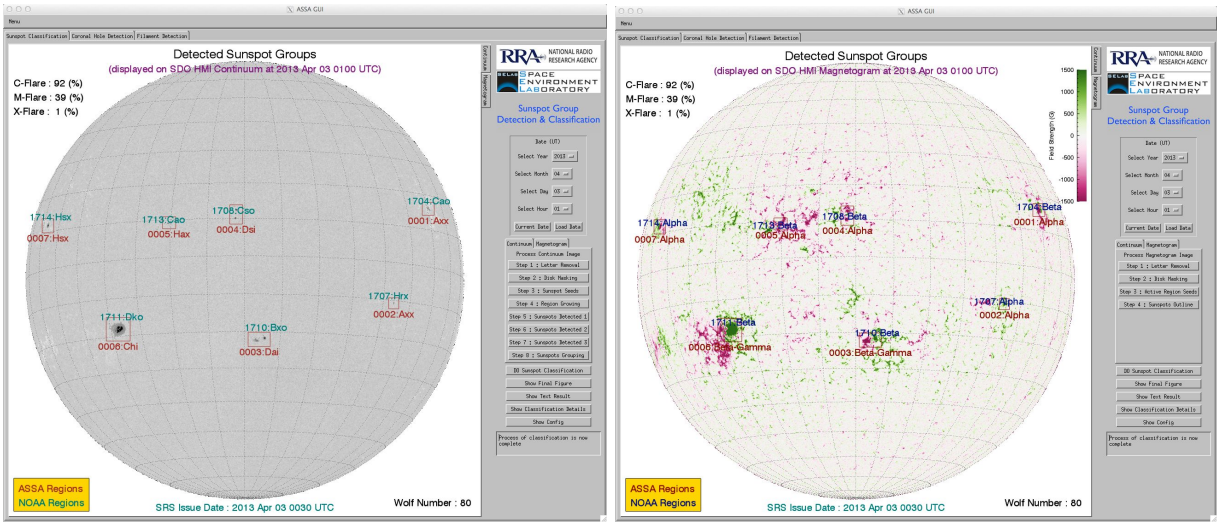


For example, the above figure shows the status when “Step 6” button on “Continuum” tab is

pressed and the corresponding process is done. As can be seen, the resultant image from “Step 6” is displayed and “Step 7” button becomes active. It doesn’t matter “Step 1” button on which tab is first pressed. In any way, all “Step” buttons on both tabs will be highlighted in order.

- Classification

After all procedures for continuum and magnetogram images are finished, “Do Sunspot Classification” button becomes active. Pressing this button invokes the procedure for estimation of McIntosh and Mt. Wilson magnetic class for each identified sunspot group. This procedure may take some time from a few tens of seconds to a few minutes depending on CPU performance. After the classification procedure is completed, the classification results are shown overlapped on each image, as follows. These final resultant images looks the same as those images available on ASSA web page of RRA.



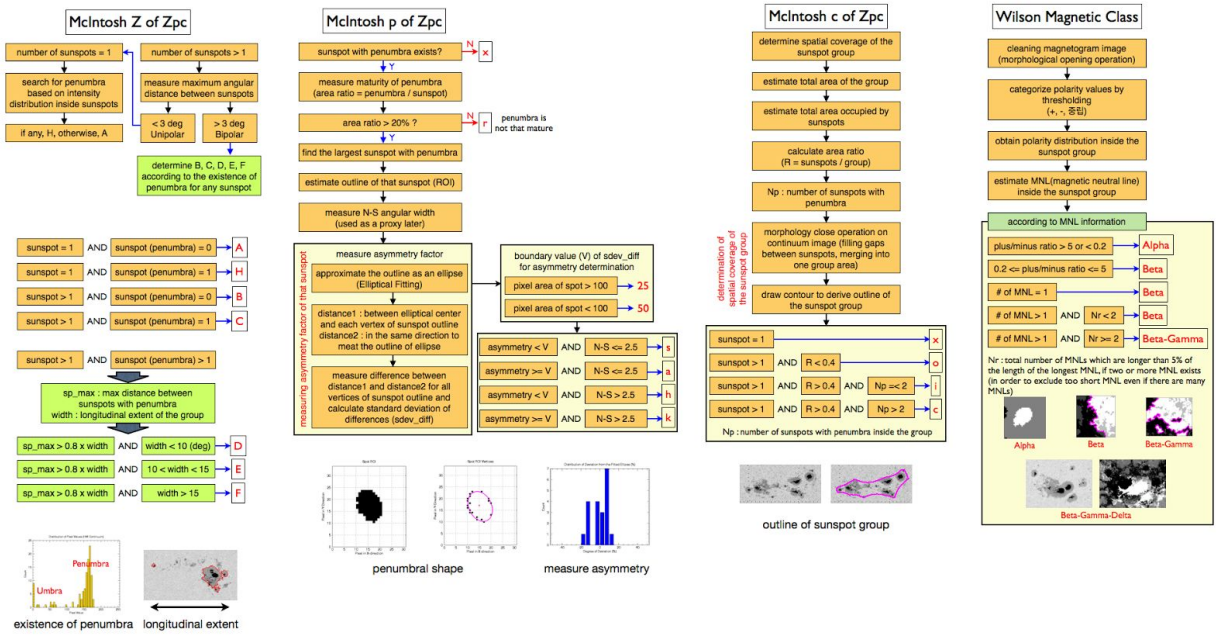
3.4 Result

- Description on the results of sunspot classification

In ASSA GUI, sunspot classification consists of McIntosh classification and Mt. Wilson magnetic classification. The algorithms developed for McIntosh classification is applied to each sunspot group identified on continuum image, in order to determine Zpc class of each group. The algorithms developed for Mt. Wilson magnetic classification is applied to each sunspot group superposed on magnetogram image, in order to determine magnetic class of each group. The basic concept of classifications described by SIDC(Solar Influences Data Analysis Center) in the following link has been mainly referred in order to develop algorithms for classification process in ASSA.

http://sidc.oma.be/educational/classification.php

The pioneering work of digital implementation of sunspot classification by Colak and Qahwaji (2007) was also referred in developing the classification algorithms for this program. The detailed work flow of both classification process in ASSA is shown in the following figure. As the figure shows, many kinds of quantitative parameters are estimated to be used for class decision. The key parameters will be summarized at the following section.

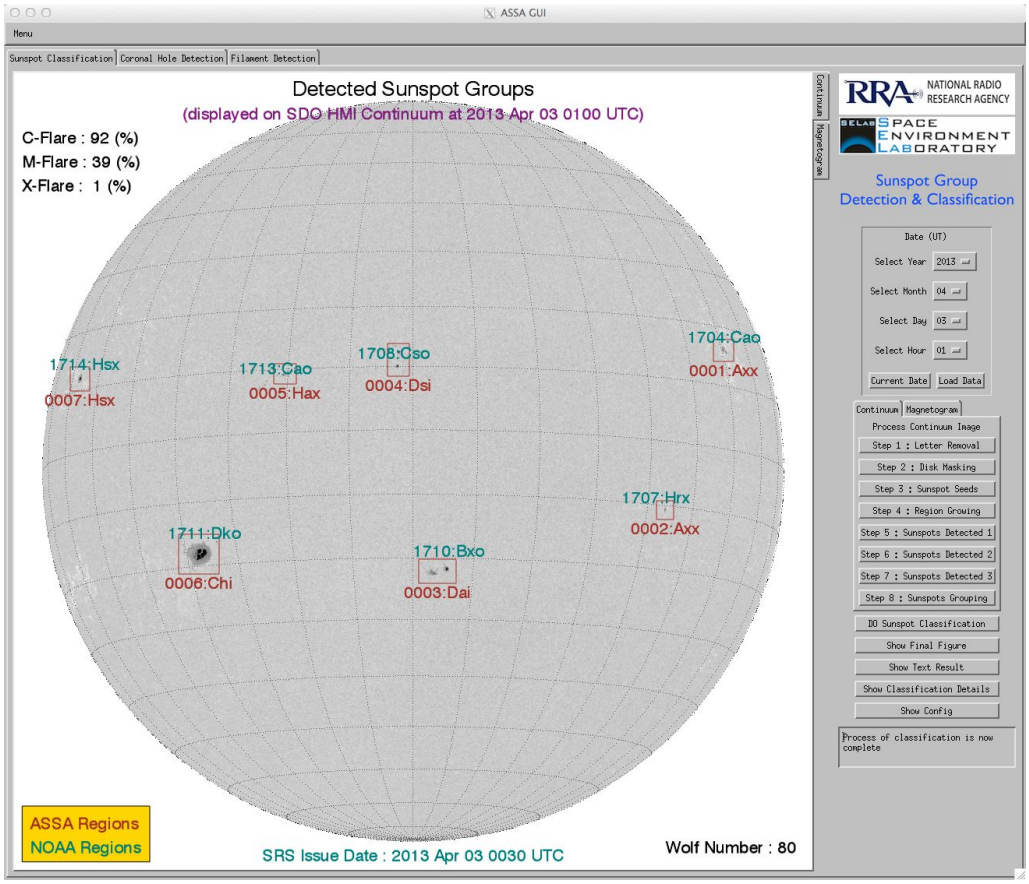

McIntosh Z of Zpc
number of sunspots = 1
number of sunspots > 1
search for penumbra based on intensity distribution inside sunspots
measure maximum angular distance between sunspots
if any, H, otherwise, A
< 3 deg Unipolar
> 3 deg Bipolar
determine B, C, D, E, F according to the existence of penumbra for any sunspot
sunspot = 1 AND sunspot (penumbra) = 0 → A
sunspot = 1 AND sunspot (penumbra) = 1 → H
sunspot > 1 AND sunspot (penumbra) = 0 → B
sunspot > 1 AND sunspot (penumbra) = 1 → C
sunspot > 1 AND sunspot (penumbra) > 1
sp_max : max distance between sunspots with penumbra width : longitudinal extent of the group
sp_max > 0.8 x width AND width < 10 (deg) → D
sp_max > 0.8 x width AND 10 < width < 15 → E
sp_max > 0.8 x width AND width > 15 → F
Penumbra
Umbra
existence of penumbra
longitudinal extent
McIntosh p of Zpc
sunspot with penumbra exists?
measure maturity of penumbra (area ratio = penumbra / sunspot)
area ratio > 20% ?
penumbra is not that mature
find the largest sunspot with penumbra
estimate outline of that sunspot (ROI)
measure N-S angular width (used as a proxy later)
measuring asymmetry factor of that sunspot
measure asymmetry factor
approximate the outline as an ellipse (Elliptical Fitting)
distance1 : between elliptical center and each vertex of sunspot outline
distance2 : in the same direction to meat the outline of ellipse
measure difference between distance1 and distance2 for all vertices of sunspot outline and calculate standard deviation of differences (sdev_diff)
boundary value (V) of sdev_diff for asymmetry determination
pixel area of spot > 100 → 25
pixel area of spot < 100 → 50
asymmetry < V AND N-S <= 2.5 → s
asymmetry >= V AND N-S <= 2.5 → a
asymmetry < V AND N-S > 2.5 → h
asymmetry >= V AND N-S > 2.5 → k
penumbral shape
measure asymmetry
McIntosh c of Zpc
determine spatial coverage of the sunspot group
estimate total area of the group
estimate total area occupied by sunspots
calculate area ratio (R = sunspots / group)
Np : number of sunspots with penumbra
morphology close operation on continuum image (filling gaps between sunspots, merging into one group area)
determination of spatial coverage of the sunspot group
draw contour to derive outline of the sunspot group
sunspot = 1 → x
sunspot > 1 AND R < 0.4 → o
sunspot > 1 AND R > 0.4 AND Np =< 2 → l
sunspot > 1 AND R > 0.4 AND Np > 2 → c
Np : number of sunspots with penumbra inside the group
outline of sunspot group
Wilson Magnetic Class
cleaning magnetogram image (morphological opening operation)
categorize polarity values by thresholding (+, -, 중립)
obtain polarity distribution inside the sunspot group
estimate MNL(magnetic neutral line) inside the sunspot group
according to MNL information
plus/minus ratio > 5 or < 0.2 → Alpha
0.2 <= plus/minus ratio <= 5 → Beta
# of MNL = 1 → Beta
# of MNL > 1 AND Nr < 2 → Beta
# of MNL > 1 AND Nr >= 2 → Beta-Gamma
Nr : total number of MNLs which are longer than 5% of the length of the longest MNL, if two or more MNL exists (in order to exclude too short MNL even if there are many MNLs)
Alpha
Beta
Beta-Gamma
Beta-Gamma-Delta

The classification results are overlayed on the final resultant figures. As can be seen in the following figure, the McIntosh class (Zpc) estimated for each sunspot group is written on continuum image with brown colored letters along with the group number. The same kind of information from SRS(Solar Region Summary) issued by NOAA on the same day is also written with green colored letters for comparison. The issue date of SRS used for this figure is written at the bottom with green colored letters. It should be kept in mind that SRS is issued once in a day for 00:30 UT. The date of continuum image used for this analysis is also written at the top with violet colored letters. On the upper left side of the figure, the flare probabilities for C, M, X class are written with black colored letters. On the right bottom side of the figure, the Wolf number is also written with black colored letters. The following formula is used to calculate Wolf number.

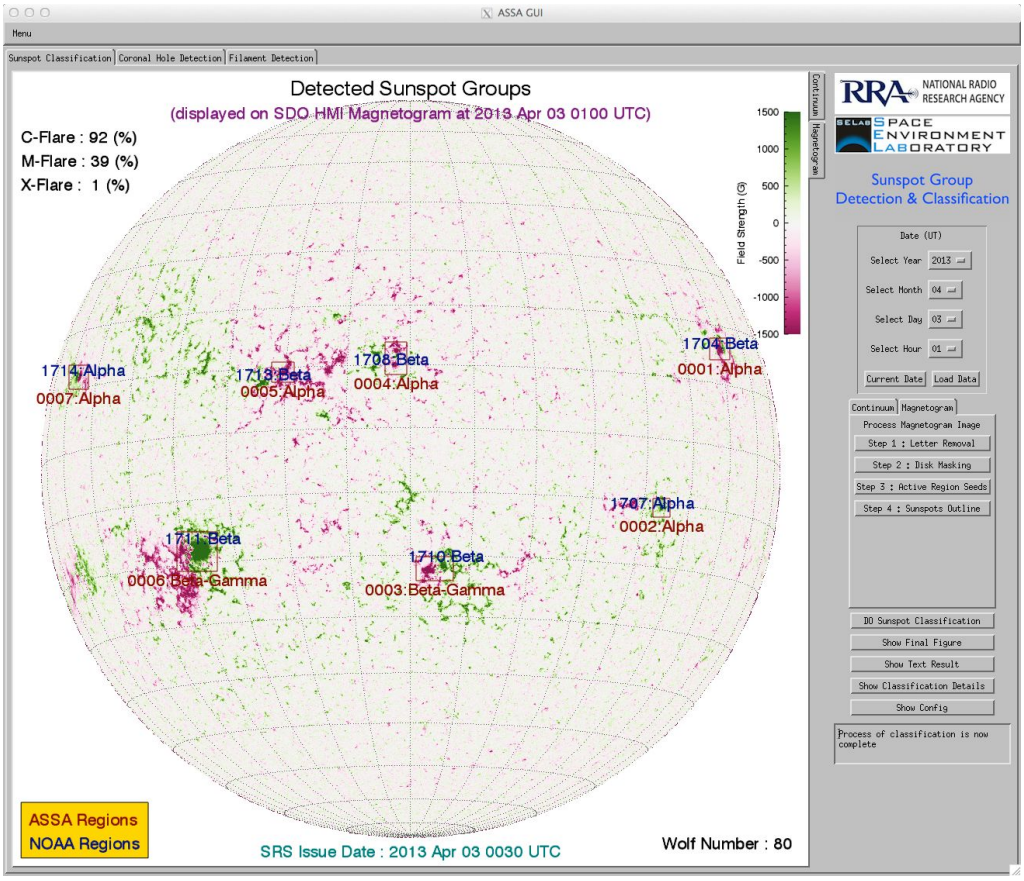
WN = k(10g+s)
s : number of individual sunspots
g : number of sunspot groups
k : correction factor (assumed to be 1.0)

The C, M, X flare probabilities are based on the result of statistical analysis of solar region and

flare data for a period of 1996~2011 which was performed by KSWC(Korea Space Weather Center). More details are described in section 3.5.



The Mt. Wilson magnetic class estimated for each sunspot group is written on magnetogram image with brown colored letters along with the group number, as seen in the following figure. The same kind of information from SRS(Solar Region Summary) issued by NOAA on the same day is also written with blue colored letters for comparison. The issue date of SRS used for this figure is written at the bottom with green colored letters. The date of magnetogram image used for this analysis is also written at the top with violet colored letters. On the upper left side of the figure, the flare probabilities for C, M, X class are written with black colored letters. On the right bottom side of the figure, the Wolf number is also written with black colored letters.



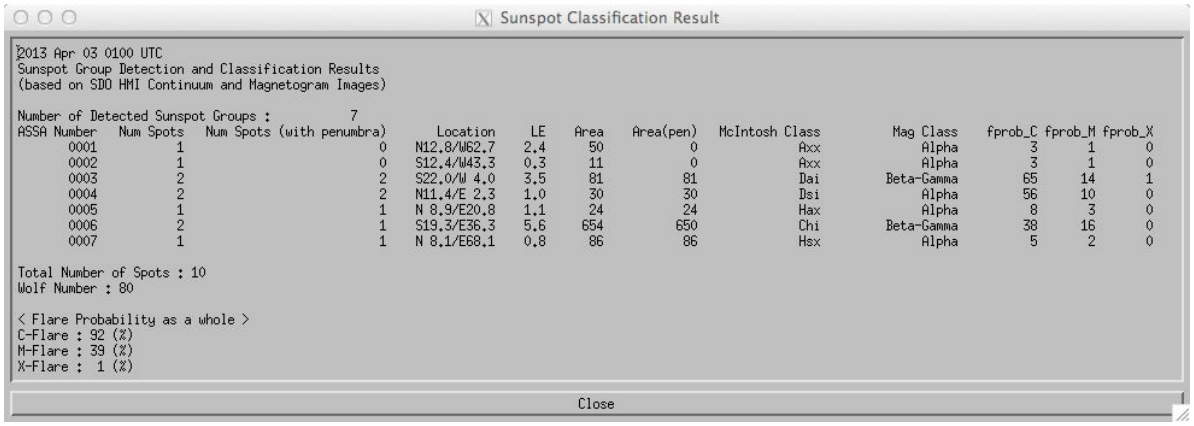
- Output files

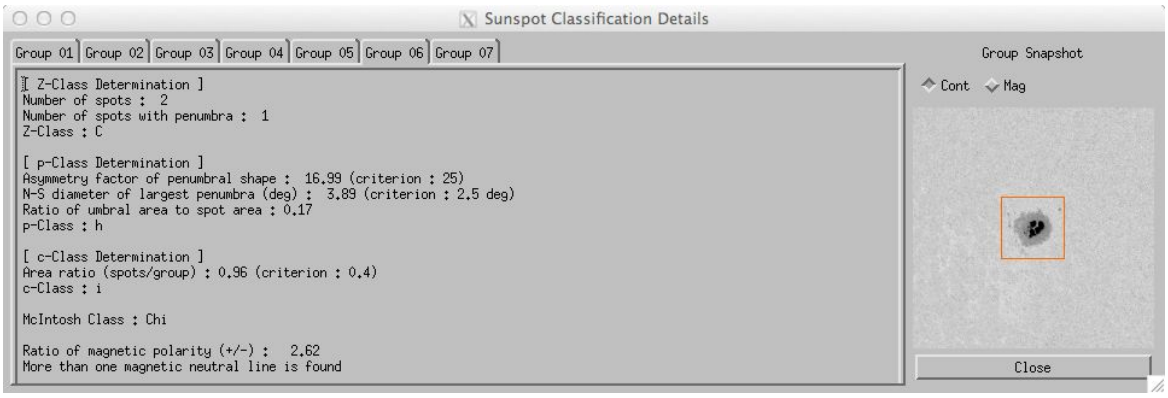
The latest output files generated after all processes are finished are automatically stored in a sub-directory called “gui_figures/ASSA”. Output images are saved as “Spot_Mci.png” and “Spot_Mag.png” for McIntosh classification result and Mt. Wilson magnetic classification result, respectively. Output text data are saved as “ASSA_Spot.txt” and “ASSA_Spot_class.txt”. “ASSA_Spot.txt” has the text resuts such as number of spots, location, area, class letter, etc. “ASSA_Spot_class.txt” more detailed informations of the parameters used for classification. These output files are also stored in directories called “gui_figures/ASSA/YYYY/MM/DD”, which are named according to the date. The other output files generated from previous job for other dates are also stored in this way, so that you can find any previous output results once you’ve worked. Just keep in mind that there’s no buttons for saving the results, as all the output files are always saved in the designated directory.

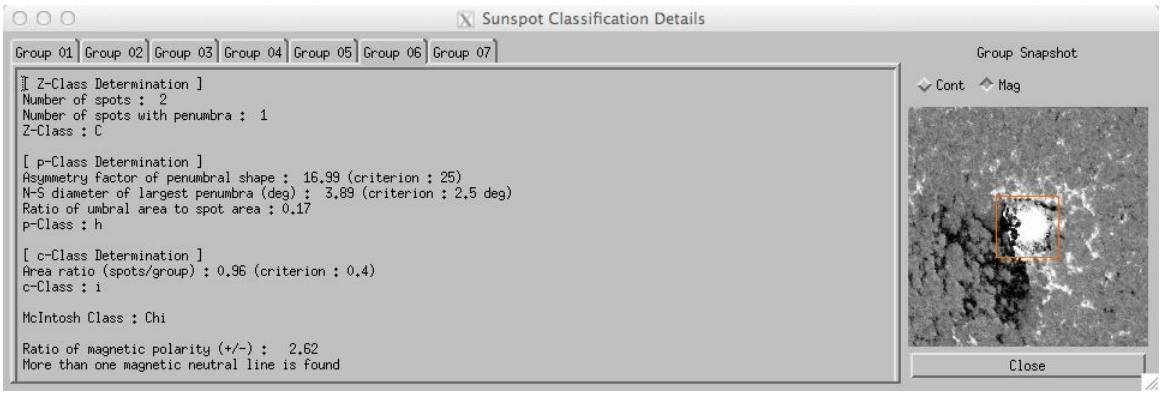
- Additional interfaces for browsing the classification results

The text results described in “ASSA_Spot.txt” can be browsed in a simple text window by pressing “Show Text Result” button. The detailed information of parameters estimated for classification can also be browsed in a simple GUI by pressing “Show Classification Details” button. Especially, this interface has tab sections for each sunspot group showing the detailed

description on how the classification result was derived. Each tab also shows the individual view of the corresponding sunspot group. The following three figures show the examples of these two interfaces for inspecting the classification result more efficiently.


Sunspot Classification Result
2013 Apr 03 0100 UTC
Sunspot Group Detection and Classification Results
(based on SDO HMI Continuum and Magnetogram Images)
Number of Detected Sunspot Groups : 7
ASSA Number Num Spots Num Spots (with penumbra) Location LE Area Area(pen) McIntosh Class Mag Class fprob_C fprob_M fprob_X
0001 1 0 N12.8/W62.7 2.4 50 0 Axx Alpha 3 1 0
0002 1 0 S12.4/W43.3 0.3 11 0 Axx Alpha 3 1 0
0003 2 2 S22.0/W 4.0 3.5 81 81 Dai Beta-Gamma 65 14 1
0004 2 2 N11.4/E 2.3 1.0 30 30 Dsi Alpha 56 10 0
0005 1 1 N 8.9/E20.8 1.1 24 24 Hax Alpha 8 3 0
0006 2 1 S19.3/E36.3 5.6 654 650 Chi Beta-Gamma 38 16 0
0007 1 1 N 8.1/E68.1 0.8 86 86 Hsx Alpha 5 2 0
Total Number of Spots : 10
Wolf Number : 80
< Flare Probability as a whole >
C-Flare : 92 (%)
M-Flare : 39 (%)
X-Flare : 1 (%)
Close


Sunspot Classification Details
Group 01 Group 02 Group 03 Group 04 Group 05 Group 06 Group 07
[Z-Class Determination]
Number of spots : 2
Number of spots with penumbra : 1
Z-Class : C
[p-Class Determination]
Asymmetry factor of penumbral shape : 16.99 (criterion : 25)
N-S diameter of largest penumbra (deg) : 3.89 (criterion : 2.5 deg)
Ratio of umbral area to spot area : 0.17
p-Class : h
[c-Class Determination]
Area ratio (spots/group) : 0.96 (criterion : 0.4)
c-Class : i
McIntosh Class : Chi
Ratio of magnetic polarity (+/-) : 2.62
More than one magnetic neutral line is found
Group Snapshot
Cont Mag
Close


Sunspot Classification Details
Group 01 Group 02 Group 03 Group 04 Group 05 Group 06 Group 07
[Z-Class Determination]
Number of spots : 2
Number of spots with penumbra : 1
Z-Class : C
[p-Class Determination]
Asymmetry factor of penumbral shape : 16.99 (criterion : 25)
N-S diameter of largest penumbra (deg) : 3.89 (criterion : 2.5 deg)
Ratio of umbral area to spot area : 0.17
p-Class : h
[c-Class Determination]
Area ratio (spots/group) : 0.96 (criterion : 0.4)
c-Class : i
McIntosh Class : Chi
Ratio of magnetic polarity (+/-) : 2.62
More than one magnetic neutral line is found
Group Snapshot
Cont Mag
Close

- Physical parameters

As described in the earlier section, there are many parameters derived in the course of classification process in order to make decision in each step. Each parameter has its default value, which is used to produce the public version of figures for classification result which are currently updated at the ASSA website of RRA. These parameters are summarized at the following table.

Key Parameters for Sunspot Classification

Parameter	Value	Unit
factor of standard deviation to be subtracted from mean intensity to determine threshold intensity for sunspot detection	6.0	None
factor of standard deviation to be applied to standard-deviation-based region growing	1.5	None
maximum separation between two sunspots to be considered to belong to the same spot group	6.0	Degree
maximum separation between sunspots to determine unipolar or bipolar	3.0	Degree
factor of group width to determine threshold of distance between spots with penumbra	0.5	None
ratio (penumbral area / entire spot area) to determine threshold of maturity of penumbra	0.2	None
threshold of asymmetry of outline ellipse of spot	25 if spot area > 100 50 if spot area < 100	None
threshold of north-south diameter of spot	2.5	Degree
threshold of ratio (sum of spot areas / entire group area) to determine compactness	0.4	None
threshold of ratio (plus polarity / minus polarity) to determine alpha or beta	0.2, 5.0	None
threshold of number of effective neutral lines separating opposite polarity to determine beta or beta-gamma	2	None

*Values are used as of Apr., 2013

It should be noted that “Show Config” button and its related functionaly for adjusting parameter values are temporarily removed in this version (1.10). This feature will come back with more key parameters available to be adjusted in the upcoming version in near future. It would be helpful to note that such key parameters still can be adjusted by editing the contents of a text file named “config_gui_SC.txt”. But it should be noted that key parameters were determined with our many tests. So please keep in mind that any anomalous results due to changes of such parameters is up to your decision.

3.5 Flare Probability

- Description on flare probability calculation

The C, M, X flare probabilities denoted on the resultant image are based on the result of statistical analysis of solar region and flare data for a period of 1996~2011 which was performed by KSWC(Korea Space Weather Center). For this analysis, past archive of GOES X-ray flare data and McIntosh class data was used to calculate average flare rate for each McIntosh class. This result was then used to determine Poisson flare probabilities for each flare class. The analysis method presented in Bloomfield et al. (2012) was adopted for this work. The entire list of the result is shown in the following figure.

McIontosh Region Classes	tblRegions (1996-2011) OnDisk	C	M	X	SWPC (1988-1996) OnDisk	C	M	X	Kildahl (1969-1976) OnDisk	C	M	X	Combined Flare Rate C	M	X	Poisson Flare Prob(%) C	M	X
AXX	2271	65	5	1	2748	82	10	0	2517	75.1	31	3	0.03	0.01	0.00	3	1	0
BXI	7	0	0	0	0	0	0	0	334	0.0	20	0	0.00	0.06	0.00	0	6	0
BXO	2736	155	8	0	3342	217	18	1	1906	123.8	41	2	0.06	0.01	0.00	6	1	0
CAI	27	11	2	0	27	14	6	0	166	86.1	19	0	0.51	0.12	0.00	40	12	0
CAO	1236	273	24	0	1455	361	38	2	232	57.6	18	1	0.24	0.03	0.00	21	3	0
CHI	3	1	0	0	2	1	0	0	29	14.5	6	0	0.49	0.18	0.00	38	16	0
CHO	81	31	5	0	88	21	2	1	112	26.7	8	1	0.28	0.05	0.01	24	5	1
CKC	1	0	0	0	0	0	0	0	0	0.0	0	0	0.00	0.00	0.00	0	0	0
CKI	8	4	2	0	17	14	6	0	28	23.1	6	2	0.78	0.26	0.04	54	23	4
CKO	139	66	13	3	135	59	11	0	52	22.7	13	2	0.45	0.11	0.02	36	11	2
CRI	4	4	0	0	6	2	0	0	152	50.7	7	0	0.35	0.04	0.00	30	4	0
CRO	754	97	13	0	745	102	3	0	368	50.4	20	2	0.13	0.02	0.00	13	2	0
CSI	9	2	0	0	14	8	2	0	211	120.6	16	2	0.56	0.08	0.01	43	7	1
CSO	2381	335	30	0	1504	284	27	0	1020	192.6	40	1	0.17	0.02	0.00	15	2	0
DAC	70	112	18	2	8	5	3	0	46	28.8	12	1	1.18	0.27	0.02	69	23	2
DAI	464	485	50	1	391	419	70	6	324	347.2	58	7	1.06	0.15	0.01	65	14	1
DAO	2069	845	102	2	1775	784	124	4	288	127.2	28	2	0.43	0.06	0.00	35	6	0
DHC	5	12	3	0	0	0	0	0	6	0.0	2	0	1.09	0.45	0.00	66	37	0
DHI	13	11	2	0	11	14	1	0	41	52.2	3	0	1.19	0.09	0.00	70	9	0
DHO	55	17	2	1	46	26	1	1	43	24.3	11	0	0.47	0.10	0.01	37	9	1
DKC	100	200	43	7	57	93	35	5	100	163.2	72	10	1.78	0.58	0.09	83	44	8
DKI	179	225	36	5	223	288	69	6	88	113.7	42	6	1.28	0.30	0.03	72	26	3
DKO	186	118	28	7	217	178	55	5	43	35.3	14	2	0.74	0.22	0.03	52	20	3
DRC	1	0	0	0	0	0	0	0	0	0.0	0	0	0.00	0.00	0.00	0	0	0
DRI	11	11	1	0	2	7	0	0	54	189.0	7	1	3.09	0.12	0.01	95	11	1
DRO	173	27	5	0	63	12	3	0	75	14.3	6	0	0.17	0.05	0.00	16	4	0
DSC	7	10	1	0	0	0	0	0	20	0.0	5	2	0.37	0.22	0.07	31	20	7
DSI	108	72	6	0	39	34	6	0	246	214.5	31	1	0.82	0.11	0.00	56	10	0
DSO	1695	423	53	1	546	198	26	1	553	200.5	51	6	0.29	0.05	0.00	25	5	0
EAC	75	116	11	3	3	5	1	0	17	28.3	6	3	1.57	0.19	0.06	79	17	6
EAI	454	561	77	4	295	370	83	2	82	102.8	48	1	1.24	0.25	0.01	71	22	1
EAO	590	374	66	2	459	267	61	0	47	27.3	10	4	0.61	0.13	0.01	46	12	1
EHC	4	10	0	0	2	9	0	0	4	18.0	8	0	3.70	0.80	0.00	98	55	0
EHI	30	54	8	0	15	24	6	0	45	72.0	28	4	1.67	0.47	0.04	81	37	4
EHO	31	29	2	0	42	31	6	0	39	28.8	6	0	0.79	0.13	0.00	55	12	0
EKC	231	567	114	18	103	278	132	17	63	170.0	149	21	2.56	0.99	0.14	92	63	13
EKI	324	455	71	10	423	703	173	23	81	134.6	103	11	1.56	0.42	0.05	79	34	5
EKO	155	133	26	1	185	173	35	3	52	48.6	20	1	0.90	0.21	0.01	60	19	1
ERO	5	2	1	0	0	0	0	0	0	0.0	0	0	0.40	0.20	0.00	33	18	0
ESC	8	8	2	0	0	0	0	0	0	0.0	0	0	1.00	0.25	0.00	63	22	0
ESI	70	66	7	0	18	33	1	0	78	143.0	22	2	1.46	0.18	0.01	77	17	1
ESO	260	93	6	0	95	37	6	0	82	31.9	14	0	0.37	0.06	0.00	31	6	0
FAC	31	56	9	0	0	0	0	0	0	0.0	0	0	1.81	0.29	0.00	84	25	0
FAI	142	237	36	0	91	106	35	3	12	14.0	8	0	1.46	0.32	0.01	77	28	1
FAO	100	77	22	2	73	63	16	0	3	2.6	0	0	0.81	0.22	0.01	56	19	1
FHC	10	33	11	0	0	0	0	0	5	0.0	4	0	2.20	1.00	0.00	89	63	0
FHI	10	24	5	0	10	17	9	0	18	30.6	15	0	1.88	0.76	0.00	85	53	0
FHO	20	12	2	0	9	5	1	0	10	5.6	0	0	0.58	0.08	0.00	44	7	0
FKC	223	614	186	32	93	233	146	24	27	67.6	39	13	2.67	1.08	0.20	93	66	18
FKI	184	388	80	9	235	517	161	17	47	103.4	106	17	2.16	0.74	0.09	89	53	9
FKO	69	68	10	0	97	165	29	1	19	32.3	6	0	1.43	0.24	0.01	76	22	1
FRO	1	0	0	0	0	0	0	0	0	0.0	0	0	0.00	0.00	0.00	0	0	0
FSC	3	3	0	0	0	0	0	0	0	0.0	0	0	1.00	0.00	0.00	63	0	0
FSI	20	30	3	0	6	12	0	0	8	16.0	15	0	1.71	0.53	0.00	82	41	0
FSO	54	28	7	0	14	9	3	0	13	8.4	6	1	0.56	0.20	0.01	43	18	1
HAX	851	78	17	0	598	49	13	0	222	18.2	14	0	0.09	0.03	0.00	8	3	0
HHX	103	17	1	0	53	3	1	0	150	8.5	16	2	0.09	0.06	0.01	9	6	1
HKX	101	15	6	1	49	11	2	0	38	8.5	7	0	0.18	0.08	0.01	17	8	1
HRX	407	14	0	0	336	21	1	0	211	13.2	7	1	0.05	0.01	0.00	5	1	0
HSX	3006	145	22	2	1968	94	21	0	1963	93.8	99	6	0.05	0.02	0.00	5	2	0
HXX	1	0	0	0	0	0	0	0	0	0.0	0	0	0.00	0.00	0.00	0	0	0

On the right bottom section of the resultant figures, flare probabilities for C, M, X class is written with black colored letters. Actually, the probability value for each flare class is a representative value for all sunspot groups on the entire solar disk. This probability for each flare class is calculated according to the following formula.

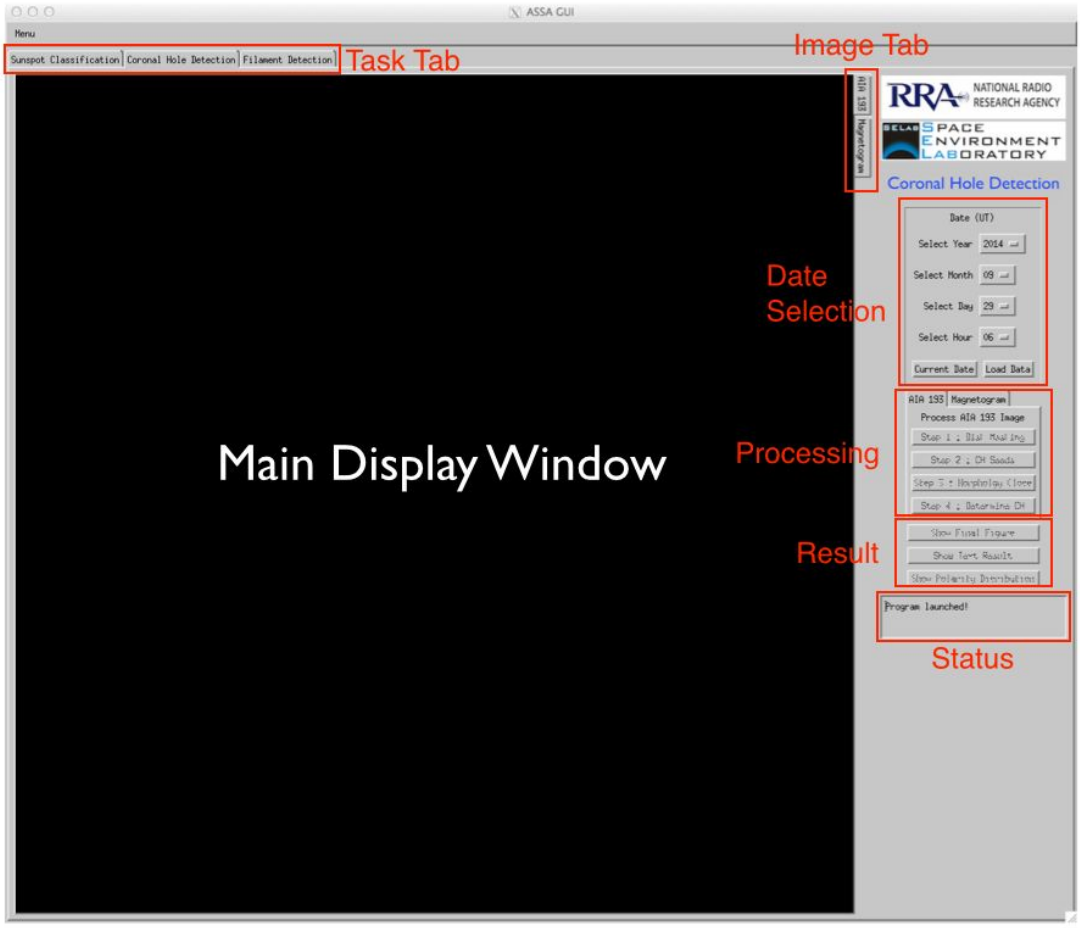
$$Prob\_total = 1 - (1-P1)*(1-P2)*(1-P3)*.....*(1-Pn)$$

Here n is the number of sunspot groups on the entire solar disk. And each P values are the Poisson probability from the above table.

4. Corona Hole Detection

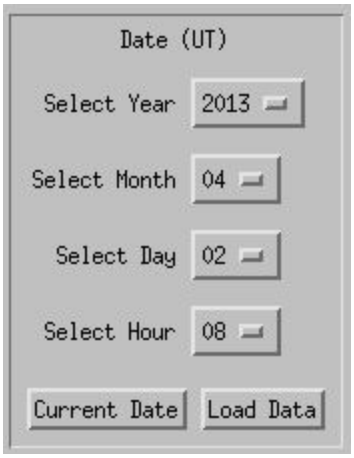
4.1 GUI Interface

If you select ‘Coronal Hole Detection’ at Task Tab, GUI for coronal hole detection becomes active, which looks like the following figure. In the ‘Coronal Hole Detection’ tab, you can identify coronal holes by processing SDO AIA 193A and HMI magnetogram images.



4.2 Getting Raw Data

Date should be specified at the interface for date selection. Year, month, day, hour can be selected for the desired UT date. Any past date may also be selected as far as it can be selected from the pull-down menus. Select the date and time in GUI as the following figure. If you click “Current Date” button, date and time will be automatically set to latest available date and time.



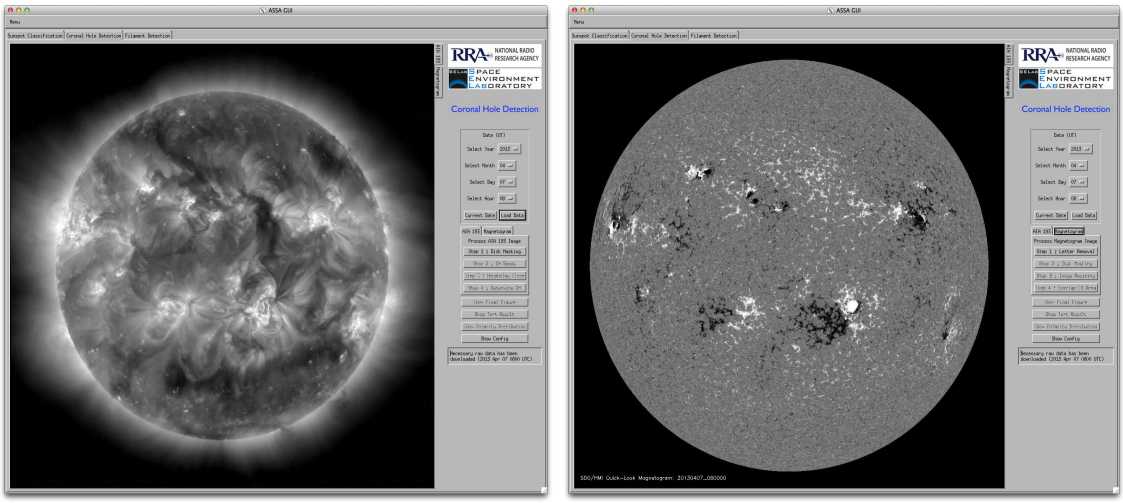
Then click “Load Data” button. ASSA program automatically checks the sub-directory called “data” to find out whether the appropriate files already exist. For sunspot classification, ASSA mainly uses SDO HMI solar continuum image(flattened) and magnetogram image named as

- [YYYY][MM][DD]_[hh][mm][ss]_1024_0193.jpg : AIA 193 image
- [YYYY][MM][DD]_[hh][mm][ss]_HMIB.jpg : magnetogram image

Additionally, UCOHO data issued daily by NOAA is also required. But in case the UCOHO data for the selected date is not available yet, the whole process continues without it. If there are no appropriate files in “data” directory, ASSA will show a pop-up window as follows.

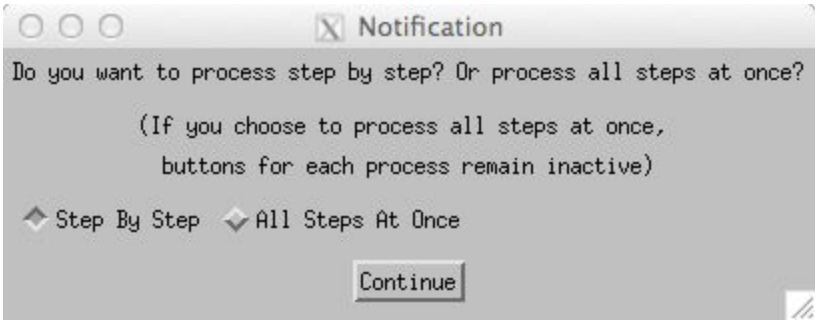
Then press “OK”, and ASSA will connect to SDO FTP archive and download the files, which are saved in ASSA data diectory(“data”). If you already have such files in your local disk and these files are named appropriately, just copy them to ASSA data directory. It also works.

When downloading SDO files is completed, ASSA will show the corresponding AIA 193 and magnetogram images on the main display window as shown in the following figure. You can switch to AIA 193 image or magnetogram image by clicking “AIA 193” and “Magnetogram” tabs of Image Tab located at upper-right side of Main Display Window.



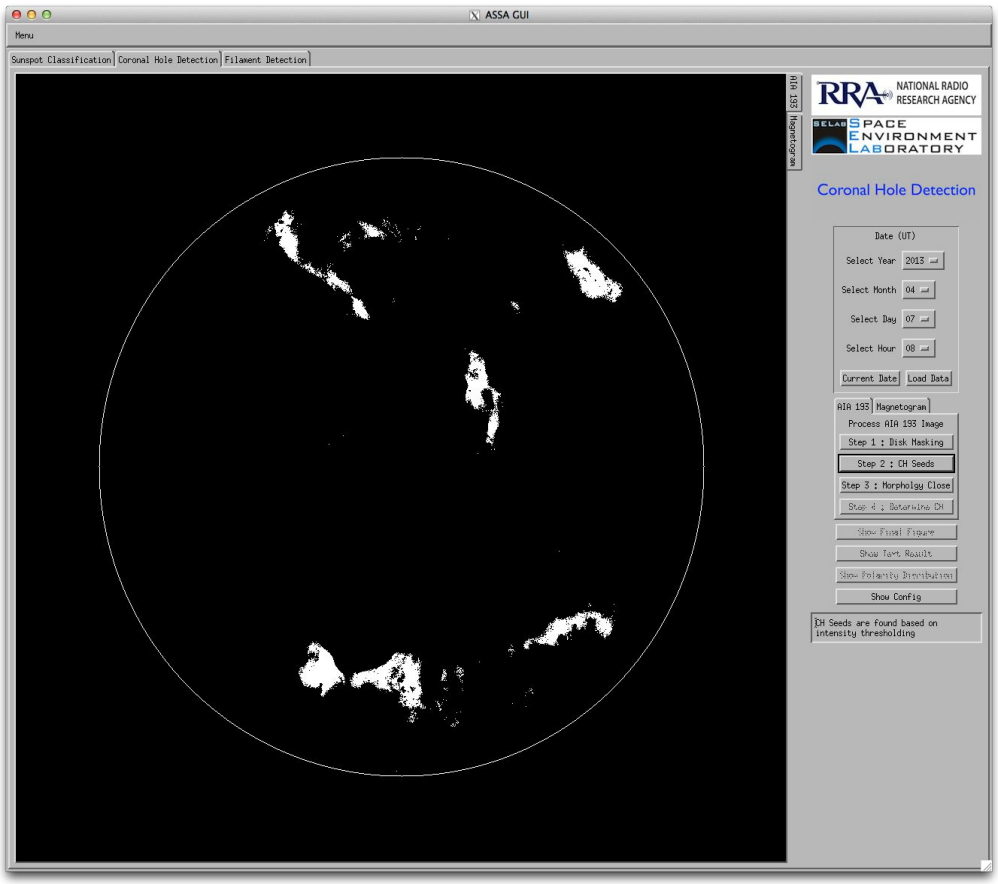
4.3 Data Processing

After the appropriate data files are successfully downloaded and displayed, you may choose either to process all steps one by one by pressing each button or to process all steps at once automatically in order, in a pop-up window which looks as follows. Choose an option and press “Continue” button.


Notification
Do you want to process step by step? Or process all steps at once?
(If you choose to process all steps at once,
buttons for each process remain inactive)
Step By Step
All Steps At Once
Continue

If you choose to process all steps at once automatically in order, you have only to wait for all processes to be completed. If you choose to process all steps one by one, “Step 1” button for “AIA 193” and “Magnetogram” tab becomes active. By pressing “Step 1” button, the first procedure for data processing is performed. After it’s done, the button for the next procedure “Step 2” becomes active, and so on. The remaining buttons become active according to the designated order of process, which intuitively indicate what to do next for users. For every step, the display window shows the image resulting from that stage of process. Therefore, users can recognize what is done for each process every step of the way. For every step, the display window shows the image resulting from that stage of process. For example, the following figure shows the status when “Step 2” button on “AIA 193” tab is pressed and the corresponding process is done. As can be seen, the resultant image from “Step 2” is displayed and “Step 3” button becomes active. It doesn’t matter “Step 1” button on which tab is first pressed. In any

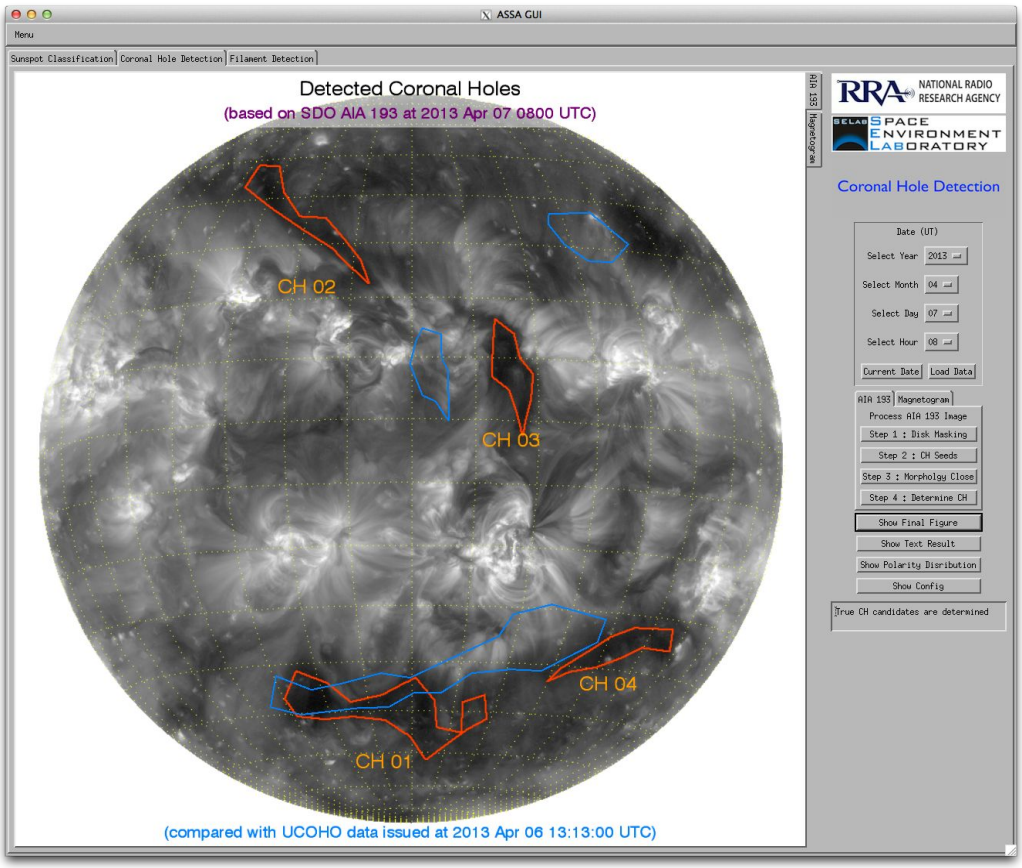
way, all “Step” buttons on both tabs will be highlighted in order.



4.4 Result

- Description on result of corona hole detection

After all necessary steps are completed, the final result is displayed by pressing “Show Final Result” button, as seen in the following figure. The polygons with red solid line correspond to the detected coronal holes by ASSA, whereas the polygons with blue solid line correspond to the coronal hole reported by UCOHO data issued for the same day by SWPC. UCOHO results are shown just for comparison.



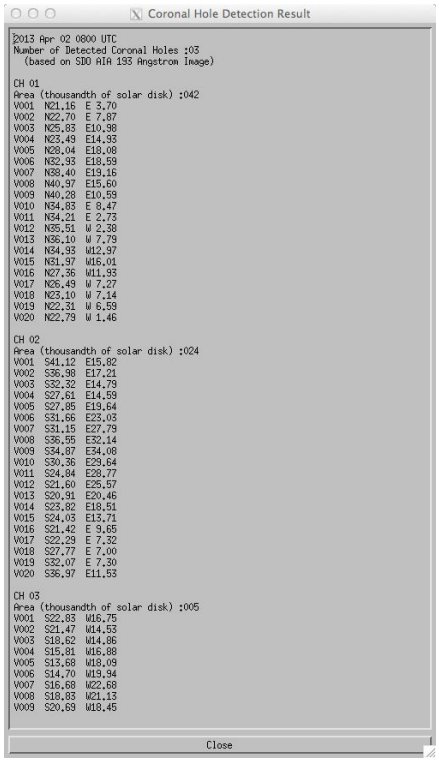
- Output files

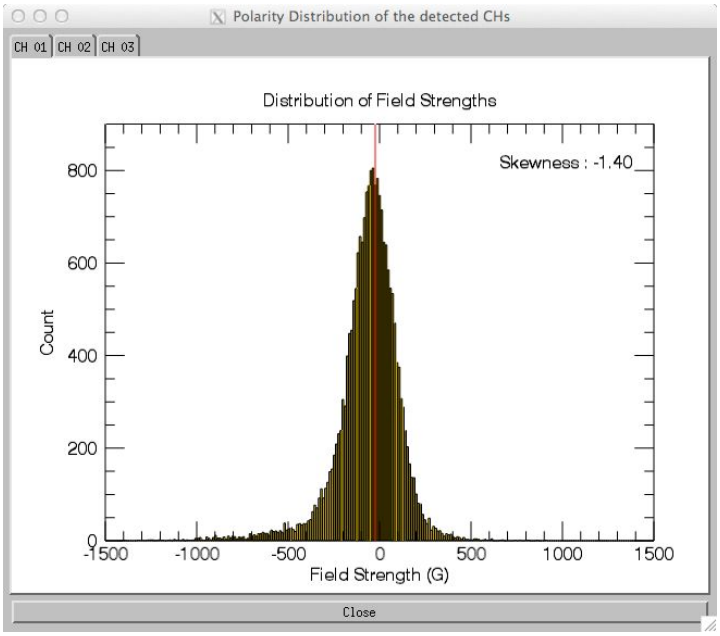
The latest output files generated after all processes are finished are automatically stored in a sub-directory called “gui_figures/ASSA”. Output image is saved as “C_Hole.png”. Output text data is saved as “ASSA_Hole.txt”, which has the text resuts such as number of coronal holes, serial number, area, location of vertices, etc. These output files are also stored in directories called “gui_figures/ASSA/YYYY/MM/DD”, which are named according to the date. The other output files generated from previous job for other date are also stored in this way, so that you can find any previous output results once you’ve worked. Just keep in mind that there’s no buttons for saving the results, as all the output files are always saved in the designated directory.

- Additional interfaces for browsing the detection results

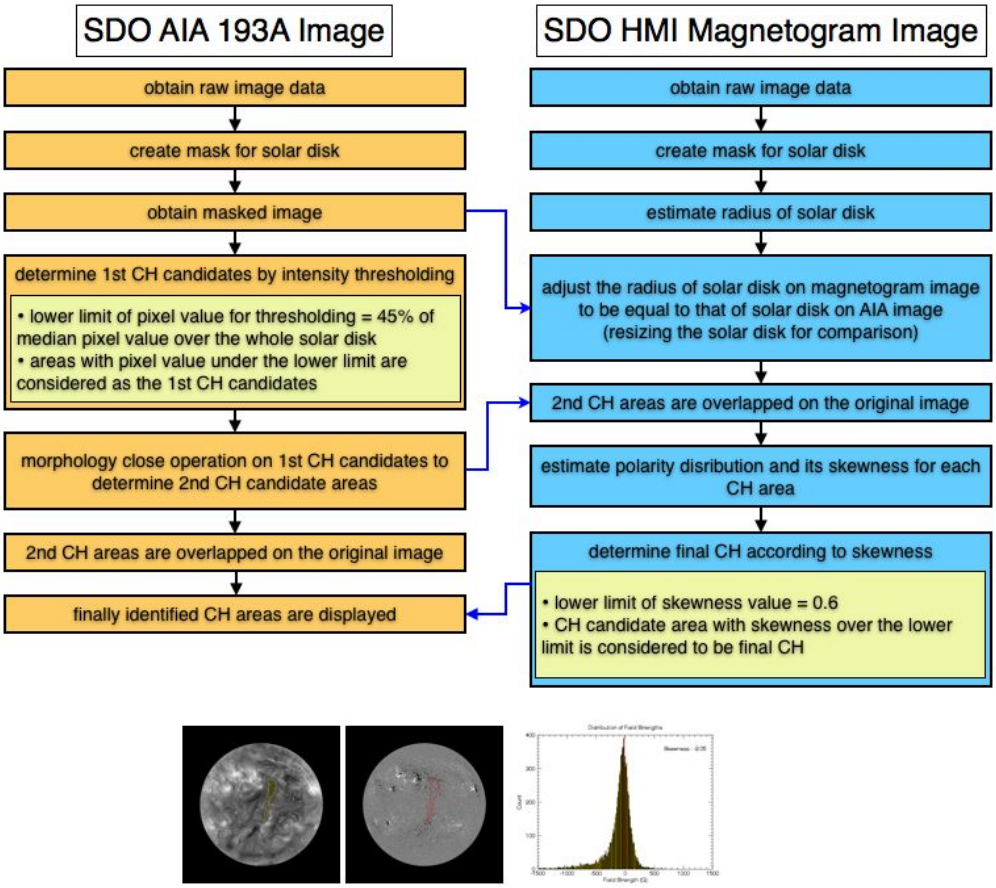
The text results described in “ASSA_Hole.txt” can be browsed in a simple text window by pressing “Show Text Result” button. The distribution of magnetic polarity inside each coronal hole can also be browsed in a simple GUI by pressing “Show Polarity Distribution” button. Especially, this interface has tab sections for each coronal hole showing each distribution plot. The following two figures show the examples of these two interfaces for inspecting the detection

result more efficienly.





The detailed work flow of coronal hole detection in ASSA is shown in the following figure. It should be noted that the distribution of magnetic polarity inside each candidate area ofcoronal hole is examined. This is based on the final decision method of differentiating coronal holes from filaments, described in Krista and Gallagher (2009). If the skewness of distribution is sufficiently far from zero, the corresponding area can be regarded as a coronal hole. As the work flow in the following figure shows, many kinds of quantitative parameters are estimated to be used for decision. The key parameters will be summarized at the following section.


SDO AIA 193A Image
obtain raw image data
create mask for solar disk
obtain masked image
determine 1st CH candidates by intensity thresholding
• lower limit of pixel value for thresholding = 45% of median pixel value over the whole solar disk
• areas with pixel value under the lower limit are considered as the 1st CH candidates
morphology close operation on 1st CH candidates to determine 2nd CH candidate areas
2nd CH areas are overlapped on the original image
finally identified CH areas are displayed
SDO HMI Magnetogram Image
obtain raw image data
create mask for solar disk
estimate radius of solar disk
adjust the radius of solar disk on magnetogram image to be equal to that of solar disk on AIA image (resizing the solar disk for comparison)
2nd CH areas are overlapped on the original image
estimate polarity disribution and its skewness for each CH area
determine final CH according to skewness
• lower limit of skewness value = 0.6
• CH candidate area with skewness over the lower limit is considered to be final CH

- Physical parameters

As described in the earlier section, there are many parameters derived in the course of coronal hole detection in order to make crucial decision in some steps. Each parameter has its default value, which is used to produce the public version of figures for classification result which are currently updated at the ASSA website of RRA. These parameters are summarized at the following table.

Key Parameters for Coronal Hole Detection

Parameter	Value	Unit
factor of median intensity of solar disk to determine candidates for coronal hole	0.45	None
lower limit of absoulte skewness of magnetic polarity distribution inside coronal hole area	0.6	None
lower limit of pixel area to be regarded as a coronal hole	2000	None

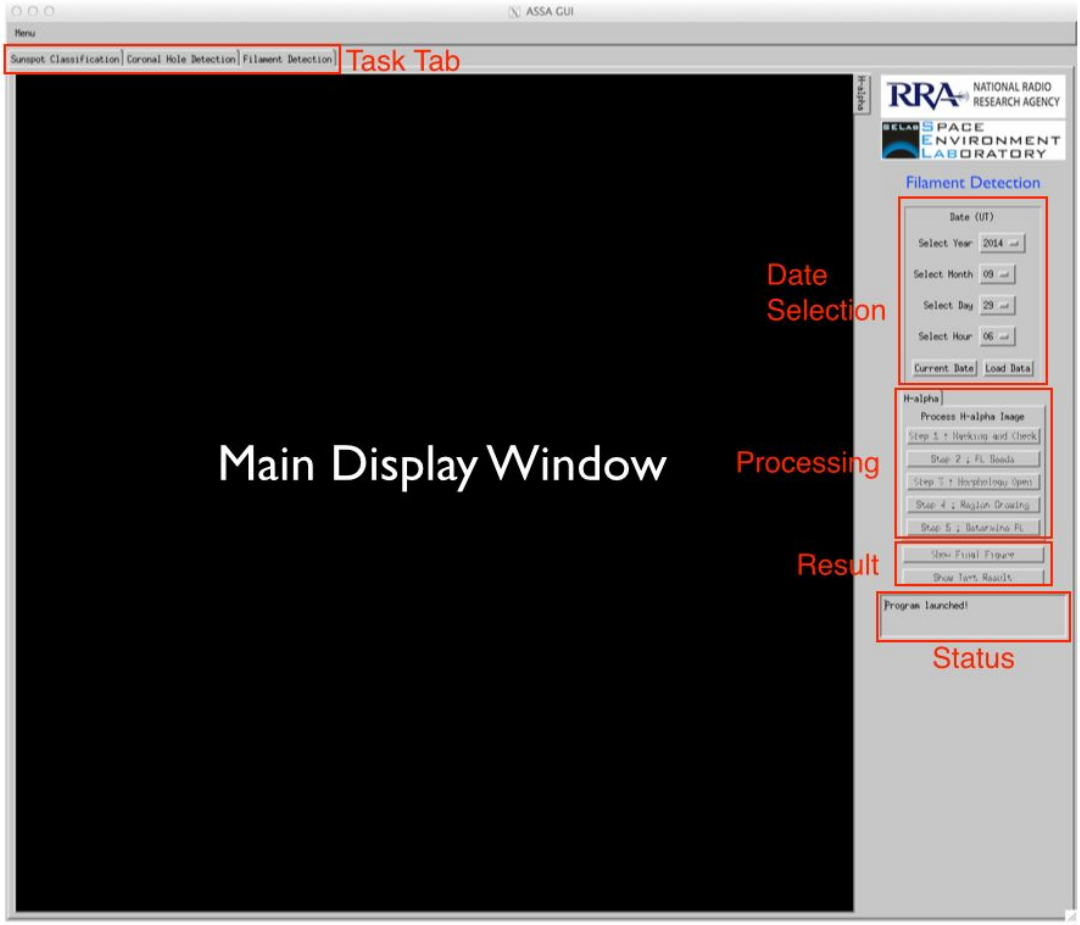
*Values are used as of Apr., 2013

5. Filament Detection

5.1 GUI Interface

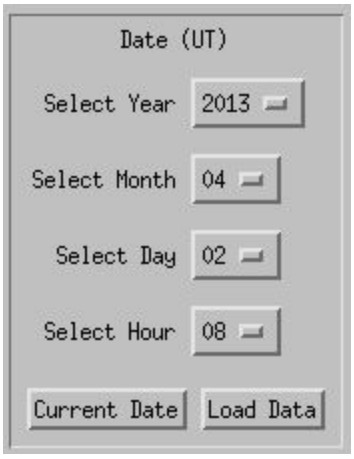
- Description on GUI of filament detection

If you select ‘Filament Detection’ at Task Tab, GUI for filament detection becomes active, which looks like the following figure. In the ‘Filament Detection’ tab, you can identify filaments by processing GONG H-alpha images.



5.2 Getting Raw Data

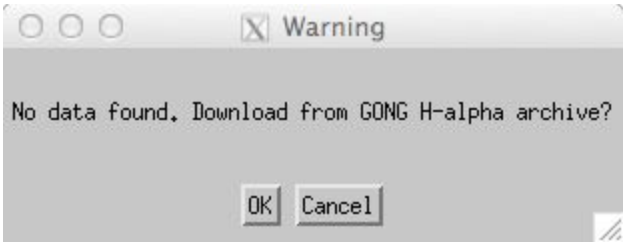
Date should be specified at the interface for date selection. Year, month, day, hour can be selected for the desired UT date. Any past date may also be selected as far as it can be selected from the pull-down menus. Select the date and time in GUI as the following figure. If you click “Current Date” button, date and time will be automatically set to latest available date and time.



Then click “Load Data” button. ASSA program automatically checks the sub-directory called “data” to find out whether the appropriate files already exist. For sunspot classification, ASSA mainly uses H-alpha image from Big Bear or Learmonth or El Teide named as

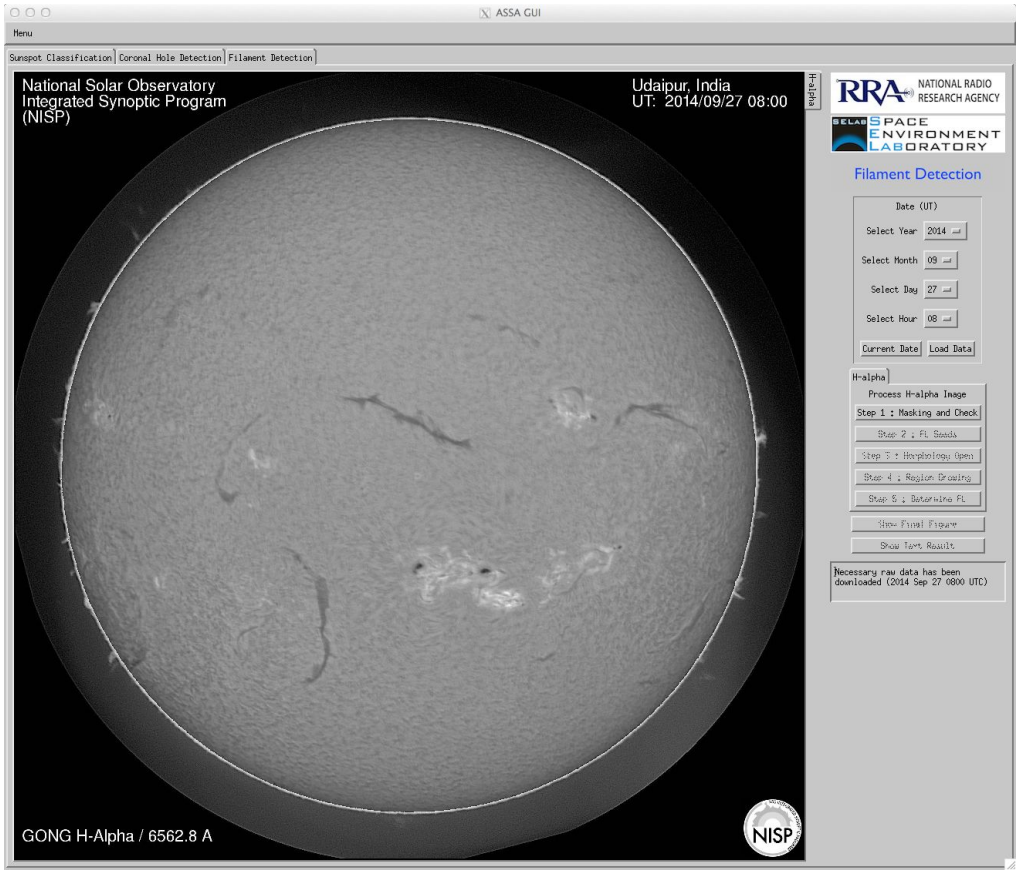
- [YYYY][MM][DD][hh][mm][ss]Bh.jpg : H-alpha image from Big Bear
- [YYYY][MM][DD][hh][mm][ss]Lh.jpg : H-alpha image from Learmonth
- [YYYY][MM][DD][hh][mm][ss]Th.jpg : H-alpha image from El Teide

The choice of image file to be downloaded depends upon the operation hour of each observatory. The coverage hour for Big Bear data is 16~23 UT, 00~07 UT for Learmonth, and 08~15 UT for El Teide. It should be noted that only those image files for available hours can be downloaded. If there are no appropriate data files in “data” directory, ASSA will show a pop-up window as follows.



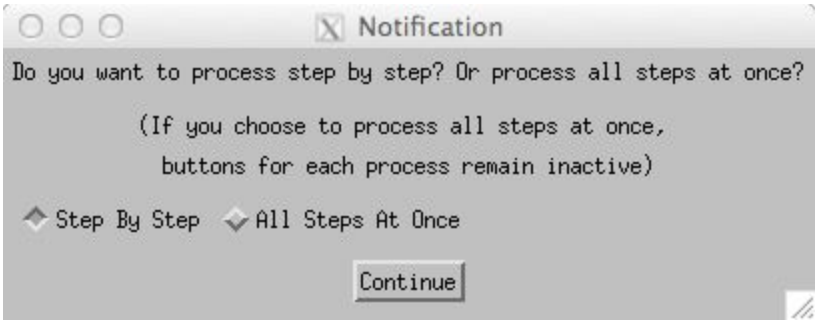
Then press “OK”, and ASSA will connect to GONG H-alpha FTP archive and download the files, which are saved in ASSA data diectory(“data”). If you already have such files in your local disk and these files are named appropriately, just copy them to ASSA data directory. It also works.

When downloading H-alpha files is completed, ASSA will show the corresponding H-alpha raw image on the main display window as shown in the following figure.



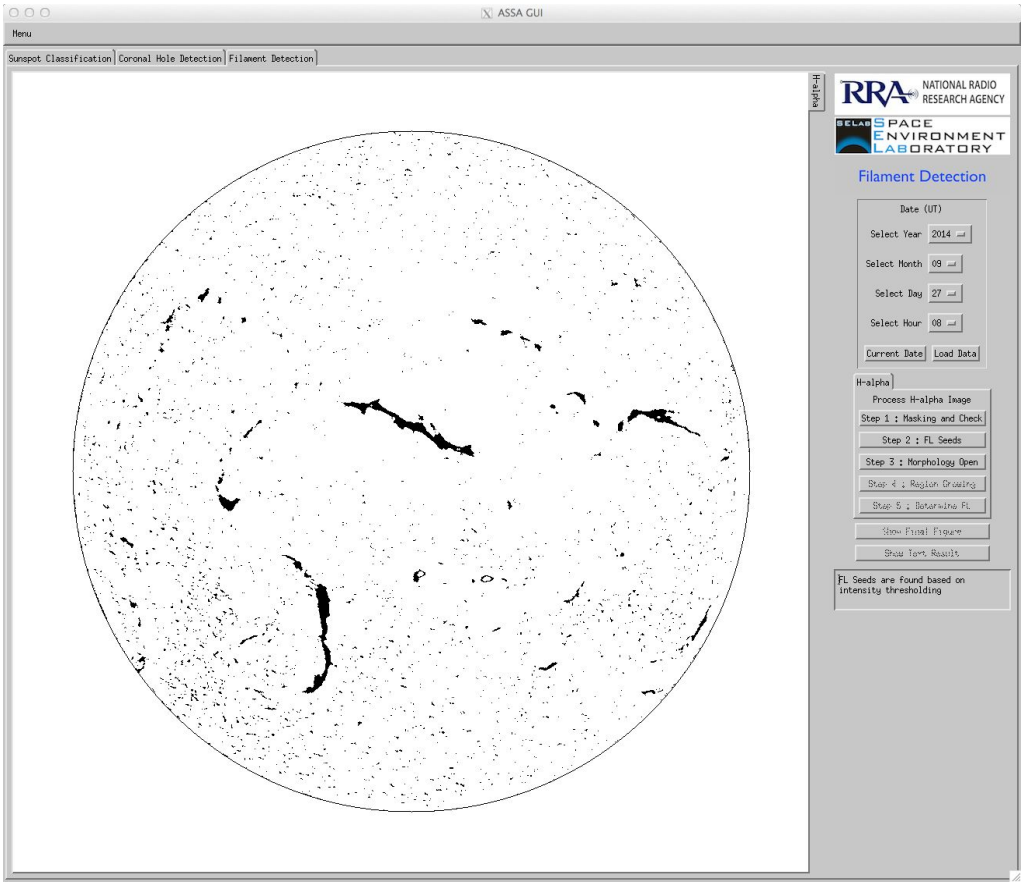
5.3 Data Processing

After the appropriate data files are successfully downloaded and displayed, you may choose either to process all steps one by one by pressing each button or to process all steps at once automatically in order, in a pop-up window which looks as follows. Choose an option and press “Continue” button.


Notification
Do you want to process step by step? Or process all steps at once?
(If you choose to process all steps at once,
buttons for each process remain inactive)
Step By Step
All Steps At Once
Continue

If you choose to process all steps at once automatically in order, you have only to wait for all processes to be completed. If you choose to process all steps one by one, “Step 1” button for “AIA 193” and “Magnetogram” tab becomes active. By pressing “Step 1” button, the first

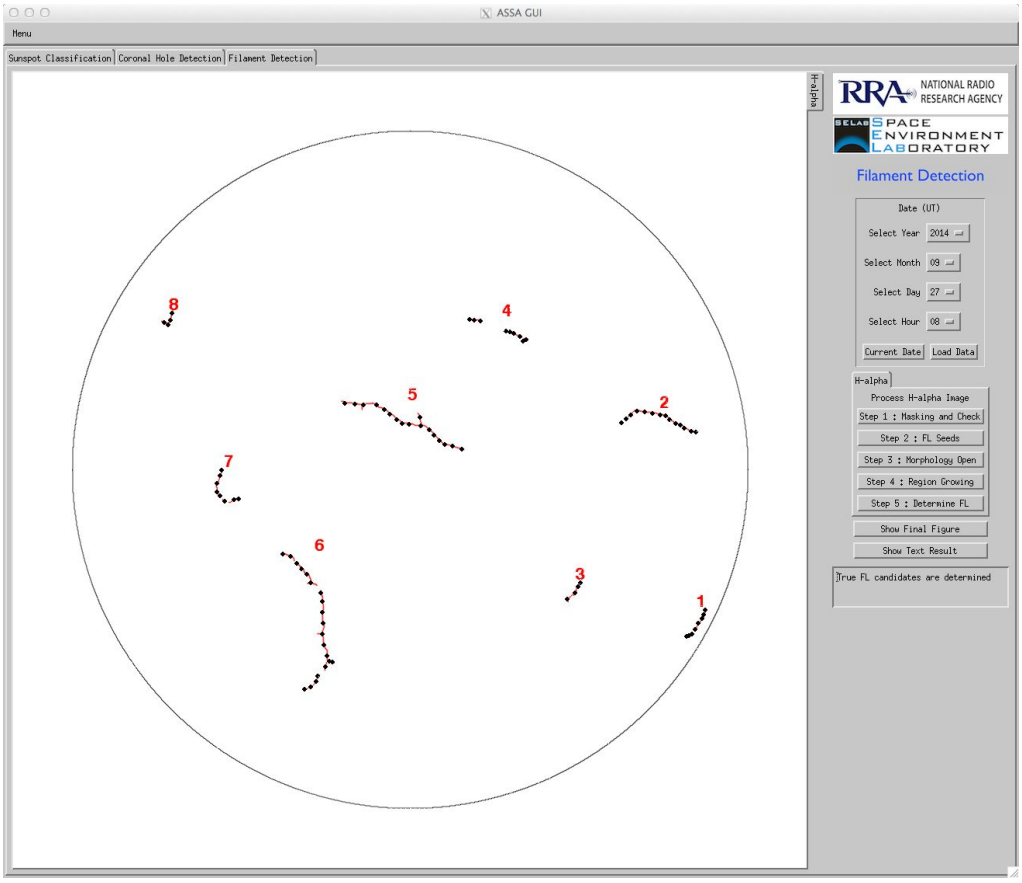
procedure for data processing is performed. After it's done, the button for the next procedure "Step 2" becomes active, and so on. The remaining buttons become active according to the designated order of process, which intuitively indicate what to do next for users. For every step, the display window shows the image resulting from that stage of process. Therefore, users can recognize what is done for each process every step of the way. For every step, the display window shows the image resulting from that stage of process. For example, the following figure shows the status when "Step 2" button is pressed and the corresponding process is done. As can be seen, the resultant image from "Step 2" is displayed and "Step 3" button becomes active. Likewise, all "Step" buttons will be activated in order.



5.4 Result

- Description on result of filament detection

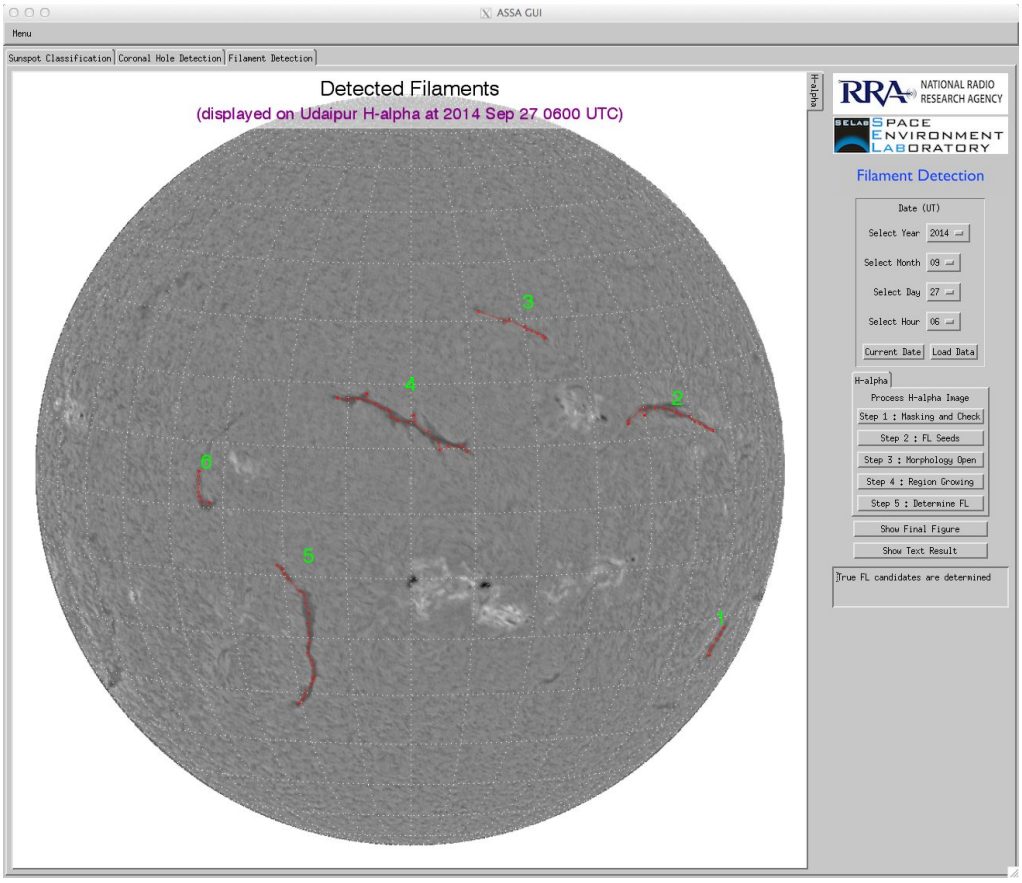
After "Step 5" button is press, the result typically looks like the following figure. The red lines correpsond to the "skeleton" of each filament, with the black dots correspond to the vertices connecting such skeleton lines. This is the main result of filament detection. The next and final result is just a mixture of this and the masked H-alpha image.



The final result of filament detection is displayed by pressing “Show Final Figure” button, as seen in the following figure.

- Output files

The latest output files generated after all processes are finished are automatically stored in a sub-directory called “gui_figures/ASSA”. Output image is saved as “Filaments.png”. Output text data is saved as “ASSA_Filaments.txt”, which has the text resuts such as number of filaments, serial number, length, location of vertices, etc. These output files are also stored in directories called “gui_figures/ASSA/YYYY/MM/DD”, which are named according to the date. The other output files generated from previous job for other dates are also stored in this way, so that you can find any previous output results once you’ve worked. Just keep in mind that there’s no buttons for saving the results, as all the output files are always automatically saved in the designated directory.



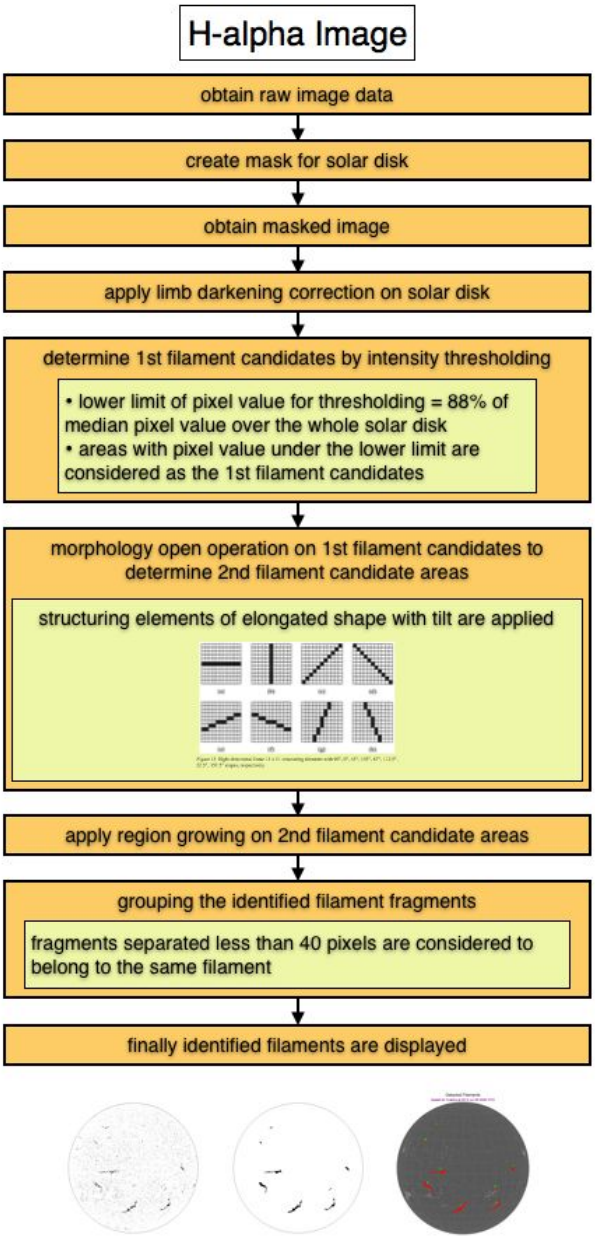
- Additional descriptions on filament detection

Filament detection requires ground H-alpha image. There's no H-alpha images not only routinely observed by satellite but also being provided to the public in realtime. GONG H-alpha archive provides near realtime H-alpha data observed at some representative ground solar observatories. The available observing hour differs from observatory to observatory. In ASSA system, H-alpha images from Big Bear, Learmonth and El Teide Solar Observatory are used, because their entirely different time coverage in UT(as follows) makes it possible to cover as many hours as possible.

(1) Learmonth : 00~07 UT
(2) El Teide : 08~15 UT
(3) Big Bear : 16~23 UT

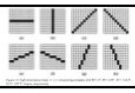
The detailed work flow of filament detection in ASSA is shown in the following figure. It should be noted that morphology opening plays a very important role in discriminating features of elongated shape typical of filaments. For this purpose, structuring elements of elongated shape with various direction angles are used for morphological opening (Shih and Kowalsky 2003). As the figure shows, many kinds of quantitative parameters are estimated to be used for decision.

The key parameters will be summarized at the following section.


H-alpha Image
obtain raw image data
create mask for solar disk
obtain masked image
apply limb darkening correction on solar disk
determine 1st filament candidates by intensity thresholding
• lower limit of pixel value for thresholding = 88% of median pixel value over the whole solar disk
• areas with pixel value under the lower limit are considered as the 1st filament candidates
morphology open operation on 1st filament candidates to determine 2nd filament candidate areas
structuring elements of elongated shape with tilt are applied
apply region growing on 2nd filament candidate areas
grouping the identified filament fragments
fragments separated less than 40 pixels are considered to belong to the same filament
finally identified filaments are displayed

As described in the earlier section, there are many parameters derived in the course of filament detection in order to make crucial decision in some steps. Each parameter has its default value, which is used to produce the public version of figures for classification result which are currently updated at the ASSA website of RRA. These parameters are summarized at the following table.

Key Parameters for Filament Detection

Parameter	Value	Unit
factor of median intensity of solar disk to determine candidates for filament	0.82	None
factor of median intensity of solar disk to determine candidates for sunspot	0.65	None
factor of standard deviation to be applied to standard-deviation-based region growing	2.0	None
structuring elements for detection of filament-like elongated feature		None
maximum separation between two fragments to be considered to belong to the same filament	40	Pixel

*Values are used as of Apr., 2013

- References

1. Bloomfield, D. S., Higgins, P. A., McAteer, R. T. J., Gallagher, P. T., ApJL, 747, L41, 2012
2. Colak, T., and Qahwaji, R., Solar Physics, 248, 277, 2007
3. Krista, L. D. and Gallagher, P. T., Solar Physics, 256, 87, 2009
4. Shih, F. Y. and Kowalsky, A. J., Solar Physics, 218, 99, 2003

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This software was developed at the Korean Space Weather Center of the Radio Research Agency by SELab, Inc. This software is a freeware. It is an experimental system and RRA assumes no responsibility whatsover for its use by other parties, and make no guarantees.

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<Update note on version 1.12>
1. For filament detection, the list of H-alpha observation sites was changed
(Big Bear, Udaipur ==>> Big Bear, Learmonth, El Teide)
2. Algorithms for filament detection was slightly modified to be compatible with the new data list
3. Some minor bug issues are fixed

<Update note on version 1.10>
1. FL processing for filament detection is now fully supported
2. Download link for AIA 193 images for CH detection has been changed
3. Problem of Alpha-Delta has been fixed
4. SC output files are now produced even when there's no sunspot at all
5. Flare probabilities shown on SC output files are now estimated based on the statistical analysis of the dependence of flaring probability on Zpc class obtained by applying ASSA algorithm to past archive of SOHO data archive (1996~2011)
6. N-S separation between sunspots are also considered in sunspot grouping
7. Problem of too many 'C' of Z class value has been fixed
8. Problem of multiple ROIs in disk masking has been fixed
9. Problem of showing wrong rectangular sector in 'Show Classification Details' interface has been fixed
10. Hole-shaped ROIs with minus area are now can be excluded
12. Many changes of internal algorithms as of September 2014 were fully applied
13. Screen size of main GUI is automatically adjusted by adopting scroll bars
14. Other minor problems are has been fixed

<Update note on version 1.07>
1. Pressing 'Load Data' button launches a pop-up window for choice between two options of processing ("Step By Step" or "All Steps At Once"). It should be noted that "All Steps At Once" processes all steps at once without pressing each step button, but each step button doesn't become active after finish.
2. Two kinds of area are measured for each sunspot group. One is a sum of areas of all sunspots, the other is a sum of areas of only the sunspots with penumbra. These two kinds of areas are recorded in the resultant text file (ASSA_spot.txt).
3. Longitudinal extent of each sunspot group is added to the contents of the resultant text file (ASSA_spot.txt).
4. Magnetogram image of each sunspot group can also be shown on 'Show Classification Details' interface, in addition to continuum image.
5. Numbering order of sunspot groups is reversed (W->E)
6. Some minor bug issues are fixed.

<Update note on version 1.03>
1. Method of calculating flare probabilities for entire solar disk has been changed.
2. Problem of estimating sunspot group area based on morphology close method has been fixed.

3. Problem of image view of sunspot group located near disk limb on 'Show Classification Details' interface has been fixed.
4. Problem of adjusting 'maximum separation between two spots' on 'Show Config' interface has been fixed.
5. Background color of task title string on Windows GUI is now the same as GUI background color.
6. Detected sunspot groups are now numbered according to its heliographic longitude.
7. Some minor issues are fixed.